

Assessing the behavior of typically lithophile elements under highly reducing conditions relevant to the planet Mercury

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With the data returned from the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) mission, there are now numerous constraints on the physical and chemical properties of Mercury, including its surface composition. The high S and low FeO contents observed from MESSENGER suggest a low oxygen fugacity of the present materials on the planet's surface. Most of our understanding of elemental partitioning behavior comes from observations made on terrestrial rocks, but Mercury's oxygen fugacity is far outside the conditions of those samples, estimated at approximately 3-7 log units below the Iron-Wüstite (IW) oxygen buffer, several orders of magnitude more reducing than other terrestrial bodies we have data from. With limited oxygen available, lithophile elements may instead exhibit chalcophile, halophile, or siderophile behaviors. Furthermore, very few natural samples of rocks that formed under reducing conditions (e.g., enstatite chondrites, achondrites, aubrites) are available in our collections for examination of this change in geochemical affinity. Our goal is to determine the elemental partitioning behavior of typically lithophile elements at lower oxygen fugacity as a function of temperature and pressure. Experiments were conducted at 1 GPa in a 13 mm QUICKpress piston cylinder and at 4 GPa in an 880-ton multi-anvil press, at temperatures up to 1850°C. The composition of starting materials for the experiments were designed so the final run products contained metal, silicate melt, and sulfide melt phases. Oxygen fugacity was controlled in the experiments by adding silicon metal to the samples, in order to utilize the Si-SiO₂ buffer, which is ~5 log units more reducing than the IW buffer at our temperatures of interest. The target silicate melt composition was diopside (CaMgSi₂O₆) because measured surface compositions indicate partial melting of a pyroxene-rich mantle. The results of our experiments will aid in our understanding of the fate of elements during the differentiation and thermal evolution of Mercury and other highly reducing planetary bodies.